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Positive externalities of congestion on health: A case study of chronic illness in Japan for the period 1988-2009.

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Abstract

This paper explores, using Japanese panel data for the years 1988–2009, how externalities from congestion and human capital influence deaths caused by chronic illnesses. Major findings through fixed effects 2SLS estimation were as follows: (1) during the first-half period 1988-98, the number of deaths was proportionally smaller in areas where social capital was larger. Population density and human capital, however, did not affect number of deaths; (2) during the second-half period 1999–2009, the number of deaths was proportionally smaller in more densely populated areas. In addition, human capital contributed to decease the number of deaths. Social capital, on the other hand, did not influence number of deaths. These findings suggest that human capital and positive externalities stemming from congestion make greater contributions to improving lifestyle when chronic illness increases.

JEL classification: I19; R58

Keywords: population density, education, chronic illness

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1. Introduction

It is widely acknowledged that maintenance of health in the general population is one of the major issues of government policy. Especially in developed countries, modern lifestyles are thought harmful to individual's health status, especially as reflected in the high prevalence of obesity (e.g. Chou et al, 2004; Loureiro and Nayga, 2005; Knai et al., 2007). Accordingly, a number of studies concerning obesity have been carried out in the USA (e.g. Cutler et al., 2003; Boumtje et al., 2005), Europe (e.g. Vigenerova et al., 2007; Zellner et al., 2007), and Japan (Kobayashi and Kobayashi, 2006). According to the Japanese Ministry of Health, Labour and Welfare (2004) the prevalence of obesity in men in Japan is 1.5 times greater than it was 20 years ago. Obesity is considered as a key factor causing chronic illnesses that lead to undesirable outcomes (Costa-Font and Gil, 2005).

Individual lifestyles depend on socio-economic circumstances. Previous reports have demonstrated that individual health status is better in larger cities in the USA than in small and medium ones (Ray and Ghoshi 2007).[1] This might be due not only to more economic resources such as a higher level of income (Blumenthal and Kagen, 2002)[2] but also to easier access to health care facilities and medical services (Rabinowitz and Paynter, 2002). On the other hand, congestion in urban areas tends to cause higher land prices leading to increases of housing expenditure. In addition, higher crime rates and pollution levels in urban areas may negatively affect health status. Thus it is important to evaluate the benefits and risks associated with urban living so as to determine optimal sizes of cities and populations (Henderson, 1982; Herzog and Schlottmann, 1993).

The importance of the role played by spatial density rather than size in improving productivity in companies has been emphasized by Ciccone and Hall (1996).[3] This appears to hold true also with respect to households, since the degree of congestion might be more closely related to the density of the population relative to physical space than it is to the overall population size. In densely populated areas such as Tokyo, congestion is expected to cause traffic jams, therefore inducing

[1] Family size (Koziel et al., 2004) and social capital (Kawachi et al, 1997; 1999; Islam et al., 2008) are also considered to have a significant effect on health.
[2] It was found that income improves health status (Pritchett and Summers 1997).
[3] Yamamura and Shin (2007) provide the evidence that spatial density has a critical role in economic growth in Japan.

individuals to take overloaded trains to business districts when they commute at rush hours.[4] This undoubtedly represents an exacerbation of daily life. Nonetheless, from the point of view of health, rail commuters who walk to and from local stations may have increased amount of daily exercise than those who drive to work and thus are less likely to become obese, leading to prevention of chronic illnesses. This implies that congestion could have positive externality in improvement and maintenance of health. Little evidence is available, however, on this facet of congestion. Furthermore, changing socio-economic circumstance over time may be a determinant of chronic illness prevalence. This paper mainly attempts to investigate how population density and human capital influence chronic diseases by comparing their effects between two time periods such as 1988–98 and 1999–2009 using panel data for Japan, which is a densely populated and highly educated country. Fixed effects 2SLS estimation was used to analyze the influences of population density and human capital on death rates caused by chronic illness in the two study periods.

2. Overview of modern Japan

According to the World Bank (2006), the population of Japan in 2002 was 126 million, living in 364,500 km^2, giving a population density 346 people/km^2. The population densities of the USA, Germany, and France are 30, 107, and 235 people/km^2, respectively. Hence Japan is distinctly more densely populated than many other industrialized countries. For closer investigation, let us look at the density distribution among prefectures in Japan.[5] From Figure 1, it can be seen that population density is remarkably skewed towards the lower end. Although most prefectures have a population density <500 people/km^2, there are some prefectures with >5000 people/km^2. This implies that there is a large difference in population density between urban and other areas.

The well-developed rail and subway coverage in large urban areas such as Tokyo have the effect that people tend to use public transportation system rather than

[4] One of reasons why the geographical location of manufacturing industries tends to disperse is congestion of cities (Mano and Otsuka, 2000).

[5] Japan comprises 47 prefectures. There are smaller administrative divisions such as cities and villages. Various useful figures are available at the prefecture level, but not in smaller divisions. This is why prefecture level data is used in this research.

drive automobiles. Plausible reasons for why the close-knit network of railway and metro was formed might be as follows. First, traffic jams frequently take place when driving automobiles, creating lateness for work and other engagements. Second, high land prices increase parking costs, so people are less likely to own a car. In short, congestion in urban areas raises the cost of using automobiles, increasing demand for substitute means of travel such as commuter trains and subways.

In Japan's urban life, the most crowded time of day appears morning commuting time. People take overloaded trains and walk through congested business districts. This commuting scenario is notorious and is sometimes expressed as "commuting hell." As a consequence, commuters use a great deal of energy and become fatigued. From another point of view, this is an involuntary way for people to receive regular exercise and maintain health on weekdays, although they suffer from psychological stress in the process. Thus one can presume that this unintended exercise stems from positive externality of congestion and may benefit health. If this holds true, individuals living in urban areas would be healthier than those in other areas. In general, lack of exercise and high calorie consumption is known to lead to obesity, which may result in chronic diseases; therefore the number of deaths caused by chronic diseases in a prefecture can be regarded as a proxy for the regional health status (Ministry of Health, Labor and Welfare, 2004, Costa-Font and Gil, 2005). Figure 2 (a) shows that percent deaths caused by chronic illnesses is obviously smaller urban residents than in people living in other areas, although gradual increases over time were noted in both areas.[6] Furthermore, a negative relationship between population density and number of deaths from chronic illnesses is shown in Figure 3(a). These findings are consistent with the assumption that externality of congestion benefits health. Hence we may postulate the following empirical hypothesis about the positive externality of congestion:[7]

Hypothesis 1: There are a smaller number of chronic disease-related deaths in more densely populated areas.

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[6] It should be noted that perhaps the urban population is younger and therefore would be less likely to have chronic diseases. Although calculations of percentage of deaths are required to be done using age-standardization, it cannot be done since number of deaths in each generation cannot be obtained. Hence, special attention is called for when Figure 2 is considered.

[7] We raise Hypothesis 1 from an empirical viewpoint. A foreseeable extension of this research would be to argue it theoretically.

Ray and Ghosh (2007) shed light on the relation between city size and health in the USA. Careful attention is required when considering the impact of city size and population density. In contrast to Tokyo, in American mega-cities such as Los Angeles, people ordinarily drive automobiles in daily life. The difference in this regard between Los Angeles and Tokyo may be partly due to difference of population density. In more densely populated areas, land is relatively scarce, and therefore its price becomes higher than in less densely populated areas. The scale of the city does not necessarily lead to high land prices because land prices are determined not only by population size but also by land area. In the following sections, I attempt to distinguish the effect of population density from city size when the externality of congestion is explored.

As illustrated in Figure 3(b), human capital, represented by the number of university graduates, is negatively associated with deaths from chronic illnesses, which supports the assertion of the existing literature that human capital contributes to improvement of health (Handa, 1998; Blumenthal and Kagen, 2002; Cooper et al., 2006). On the other hand, it has been reported that socio-economic conditions have different influences on health status and body mass index (BMI) in men than in women (Zellner et al, 2004; Chranowska et al. 2007). It seems appropriate that there could be differences in the effect of human capital on health between men and women, because lifestyles often differ between the sexes.

Japan ratified its "Convention on the Elimination of all Forms of Discrimination against Women" at the United Nations General Assembly in 1979.[8] The Equal Employment Opportunity Law for Men and Women was promulgated in 1985. Subsequently, its partial amendment was made in 1997 and came into force in 1999.[9] In conjunction with this, education levels for women became higher than in the past. Consequently, Japanese women were expected to rise in social standing. Nonetheless, in actuality, the labor force non-participation rates for 2000 were 51.8% for women and 25.2% for men (Statistics Bureau of Ministry of Public Management, Home Affairs, Post and Telecommunications, 2004).[10] The gap

[8] See http://www.un.org/womenwatch/daw/cedaw/.

[9] http://www.cc.matsuyama-u.ac.jp/~tamura/kintouhou.htm (in Japanese).

[10] Labor force non-participation rate is defined as below (Statistics Bureau of Ministry

between the sexes may presumably be due to many women being housewives, which counts as non-participation in the labor force. In Japan, full-time workers are expected to give devoted service to their companies and thus spend long hours and much energy in doing their jobs. Company work is considered to impose strong constraints on healthy lifestyle, even in educated workers who recognize the importance of maintaining their health. These observations lead to the conjecture that women are able to make lifestyle decisions under looser constraints than men because they generally are less likely to be full-time workers and therefore better able to allocate time and resources to health maintenance than their male counterparts. Thus educated women can put their knowledge about maintaining good health into practical use, for example by consuming healthy food. Figure 2(b) suggests that there are fewer chronic disease-related deaths in women than in men, which is in line with the above conjecture.

Undoubtedly, access to medical services is a key factor determining health status. The number of hospitals per capita can be regarded as a medical service. Contrary to this, cursory examination of Figure 3(c) reveals that the number of hospitals per capita is positively associated with deaths from chronic illnesses. This might be because hospitals tend to be located in areas where a lot of patients live. That is, there is an adverse causality between hospitals and deaths so that simple regression of Figure 3(c) cannot identify the effect of hospitals on deaths. To put it differently, endogeneity bias takes place when the proxy of medical service is incorporated. In the following section, I will attempt to control for the bias with the aim of precisely examining how medical service benefits health.

3. Data and Methods

3.1. Data

The data were aggregated at the prefecture level, comprising 46 prefectures in Japan, for the years 1988–2009.[11] The structure of the dataset used in this study was panel. Apart from *DEATH* and human capital (*HC*; rate of people graduating

of Public Management, Home Affairs, Post and Telecommunications, 2004):
(Students + homemakers + others)/persons 15-64 years old.

[11] Although Japan comprises 47 prefectures, BOOZE data was not available for the Okinawa prefecture, therefore, the data for only 46 prefectures was used for regression estimation.

from university), the sources of the data used in the regression estimations were Asahi Shimbunsha (2010) and Index Corporation (2006). Data of *DEATH* from 1988 to 2002 were obtained from Index Corporation (2006); data on 2003-09 were collected from the Ministry of Internal Affairs and Communications.[12] The Ministry of Internal Affairs and Communications also provided data related to the number of people who graduated from university: for 1980, 1990, and 2000. The data were generated by interpolation based on the assumption of constantly changing rates between 1980, 1990, and 2000. Data of 2001-09 were collected from the Ministry of Education, Culture, Sports, Science and Technology.

3.2. Econometric Framework

To test the hypotheses raised in the previous section, relations between health status and congestion as well as human capital and socio-economic circumstances were explored. Following the discussion hitherto developed, the estimated function took the following form:

$$DEATH_{its} = \alpha_1 HOSPITAL_{it} + \alpha_2 DENS\ (POP)_{it} + \alpha_3 SC_{it} + \alpha_4 INCOM_{it} + \alpha_5 HC_{it} + \alpha_6 BOOZE_{it} + \alpha_7 SERVICE_{it} + \alpha_8 AGE60_{its} + \alpha_{11} YEAR9702_t + \alpha_{12} YEAR9902_t + \nu_i + u_{its}$$

where $DEATH_{its}$ (no. deaths caused by chronic illnesses) represents the dependent variable in prefecture *i*, year *t,* and sex *s*. α represents the regression parameters. Only the values of $DEATH_{its}$ and $AGE60_{its}$ are different between men and women. ν_i, u_{its} represents the unobservable specific effects of the individual effects of prefecture *i*' (a fixed effects prefecture vector) and an error term. ν_i encompasses the time-invariant feature, while u is an error term. The descriptive statistics and definitions of independent variables are displayed in Table 1.

Special attention must be paid to the omitted variable bias stemming from unobservable individual specific effects. With the aim of controlling for this bias, fixed effects estimations were employed. *HOSPITAL* (no. hospitals) was used as an

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[12] The data is available at http://www.e-stat.go.jp/SG1/estat/NewList.do?tid=000001028897. (Accessed at April 28, 2011.)

independent variable to control for access to medical services, which is known generally to improve health status. The expected sign of *HOSPITAL* is thus negative. Additionally, to address potential endogenous problems of *HOSPITAL,* as pointed out above, fixed effects 2SLS estimations (Baltagi, 2005) were carried out to allow control of the endogeneity problem as well as unobservable individual fixed effects.

In an attempt to estimate the elasticity in comparing the magnitude of the dependent variables, the function took a linear form.[13] Accordingly, dependent and independent variables were evaluated at the sample means, and therefore the coefficient values reported can be interpreted as elasticity.[14]

3.3. Density and Human Capital

The variables on which the main stress falls are population density (*DENS*) and *HC*. They are incorporated for the purpose of examining the effect of the positive externality of congestion and human capital. If congestion induces unintended exercise and hence makes a contribution to amelioration of health problems, that is if hypothesis 1 is supported, *DENS* would take a negative sign.

3.4. Control Variables

Social capital is loosely defined as social trust or social networks, and is thought to have a significant role on human behavior (Putnam, 2000). In terms of health, various empirical studies have provided evidence that social capital is positively associated with health status (e.g. Kawachi et al., 1997, 1999; Islam, 2008). The

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[13] Unfortunately, there is no theoretical model supporting the linear form. It is beyond the scope of this paper to theoretically justify the function form. This is an issue for future study.

[14] See more details in Greene (1997, p.280).

In the linear model, $y = x'\beta + e$ the elasticity of y with respect to changes in x is

$$\gamma_k = \frac{\partial \ln y}{\partial \ln x_k} = \beta_k \left(\frac{x_k}{y} \right).$$

This value can be estimated at the sample means as

$$\lambda_k = \beta_k \left(\frac{\overline{x_k}}{\overline{y}} \right).$$

The standard error of the elasticity of y, γ_k , can be calculated by the delta method (Greene 1997, pp. 278-280).

social capital effect should thus be captured so as to evaluate its effect on health. Following previous Japanese studies (Yamamura, 2008a, 2008b, 2008c, 2008d), the number of community centers was incorporated as a proxy for social capital. The sign of *SC* was predicted to be negative.

People with high incomes can generally afford to spend more money on health care and expensive healthy food and thereby maintain their health status. Accordingly, economic factor such as per capita income (*INCOM*) is expected to have a positive sign (Pritchett and Summers 1997; Kawachi et al., 1997). It is generally known that alcohol consumption harms health, leading to the prediction of a positive sign for per capita consumption of alcohol (*BOOZE*). Moreover, in comparison with other workers, service sector workers are less likely to do physical work, equating to a relative lack of exercise.[15] As a result, the rise in the proportion of workers in service sectors is associated with lifestyle-related chronic illnesses. Therefore the coefficient of rate of employment in service sector (*SERVICE*) would be expected to take a positive sign. Older age also is known to increase the likelihood of developing chronic illness (Riley, 1991; Costa-Font and Gil, 2005). Therefore the proportion of population aged >60 years (*AGE60_*) should take a positive sign.

As mentioned earlier, the Equal Employment Opportunity Law for Men and Women was revised in 1997 and took effect in 1999. *YEAR9709* was assigned as 1 during 1997–2009 and 0 in earlier years and *YEAR9909* was assigned as 1 during 1999–2009 and otherwise was 0. These captured the changes in socio-economic circumstances, especially in women. The year dummies were used to control for changes in socio-economic circumstance and macroeconomic shock.

3.5. Instrumental Variables: Controlling for Endogeneity of Hospitals

The causality between health status and hospitals runs in both directions, thereby causing estimations to suffer from bias. In this study, fixed effects 2SLS estimation was employed so as to control for the bias (Baltagi 2005); therefore instrumental variables need to be identified. It seems plausible to assume that the

[15] It should be noted that the service sector includes not only office workers, but also shop and restaurant workers who would perhaps be active. Nevertheless, in comparison with other sectors comprising peasants, fishers, and construction laborers, workers in the service sector appear to be less active.

greater the area of the inhabited land, the greater is the number of hospitals that can exist in that given area. Therefore the area of inhabited land can be considered an appropriate instrumental variable of the number of hospitals.[16] Accordingly, the area of inhabited land and its log-form values were employed as instrumental variables.

4. Estimation Results and their Interpretation

Estimation results using data of the whole period 1988–2009 are shown in Tables 2 and 3. Further results of the first-half period 1988-98 are presented in Tables 4 and 6 whereas those of the second-half period 1999–2009 are displayed in Tables 5 and 7. The results of the fixed effects estimations are shown Tables 2, 4, and 5. The results of the fixed effects 2SLS model are presented in Tables 3, 6, and 7. In each table, columns (1) and (4) exhibit the total number of deaths caused by chronic illnesses. The results using the number of male deaths appear in columns (2) and (5) whereas those of females are in columns (3) and (6). As mentioned earlier, the values are elasticity; those in parentheses are t-values calculated using the Delta method.

4.1. Estimation during the whole period 1988–2009

With respect to access to medical services, in line with prediction, coefficients of *HOSPITAL* took negative signs and were statistically significant, with the exception of column (3). The coefficients of *DENS* demonstrated significant negative signs in columns (1)–(3), as expected. When year dummies were included, *DENS* became statistically nonsignificant in columns (4) and (5), implying that although congestion reduced male deaths from chronic illness this effect of congestion was almost controlled by year dummies. As for *INCOM*, contrary to expectation, its coefficients became positive and statistically significant at the 1% level. However, once year dummies are included, *INCOM* became negative and statistically significant at the 1% level. As is presented in columns (1)–(3), coefficients of *HC* were not statistically significant and did not show stable signs without year dummies, whereas, as predicted, coefficient signs of columns (4)–(6) were negative

[16] Although inhabited land size seems to be correlated with *DENS*, it does not appear to be correlated with the error term.

and statistically significant at the 1% level. These results indicate that controlling for macroeconomic factors led to expected results about *INCOM* and *HC*. Congruent to prediction, *SERVICE* produced significant positive sign in columns (1)–(3), whereas it was not statistically significant in columns (4)–(6). *BOOZE* and *AGE60_* yielded the expected positive sign and were statistically significant at the 1% level in all estimations, suggesting that their effects on number of deaths are robust. Concering *YEAR9709* and *YEAR9909,* the finding that their coefficients took significant positive signs in all estimations reflected that these factors led to increased numbers of deaths. As a whole, estimation results without year dummies are very different from those with year dummies. Table 3 shows that an over-identification test was used to assess the null hypothesis that instrumental variables were uncorrelated to the error term. Since the p-values of the over-identification test were 0.07 and 0.03 in columns (1) and (2), respectively, the results reject the null-hypothesis, which passed the over-identification test in all estimations. On the other hand, in columns (3)–(6), p-values of the over-identification test were >0.10, showing that the null-hypothesis was not rejected. Hence apart from columns (1) and (2), the results did not suffer from estimation bias. All in all, the results of the fixed effects 2SLS estimation were similar to those in Table 4. Hence it follows that macroeconomic and social conditions are factors that determine numbers of deaths caused by chronic illness.

4.2. Comparison of results between the periods 1988-98 and 1999–2009

In the first-half period, as presented in Table 4, signs of *HOSPITAL* and *DENS* were not stable and statistically nonsignificant, implying that these factors did not influence the numbers of death in the first period. In contrast, *SC* yielded a negative sign and was statistically significant at the 1% level in all estimations. That is, the influence of *SC* on *DEATH* was robust. Absolute coefficient values of *SC* were approximately 0.05 when year dummies were not included. These values decreased slightly to 0.04 when year dummies were incorporated, implying that 1% increase of community center per capita resulted in 0.05% decrease in number of deaths caused by chronic illness. Therefore *SC* played an important role in improvement of lifestyle and so health condition. Results of other variables such as *INCOM, HC, BOOZE*, and *SERVICE* were statistically significant when year dummies were not included but not when year dummies were included. Accordingly, their effects can be controlled by year-specific effects. *AGE60_* yielded the expected positive sign and was statistically significant in all estimations.

As shown in Table 5, *HOSPITAL* yielded a negative sign and was statistically significant in columns (1) and (3), whereas it was not statistically significant in other columns. This shows that negative effect of *HOSPITAL* can be captured by year-specific effects and therefore *HOSPITAL* did not influence *DEATH*. Consistent with the hypothesis proposed in the previous section, *DENS* took a negative sign and was statistically significant at the 1% level in all estimations. Absolute values of *DENS* ranged at 0.22-0.30 but when year dummies were included they range at 0.11-0.12. Hence, the effect of *DENS* was captured by year-specific macro factors to a certain extent. After controlling for macro factors, a 1% increase of population density led to 0.11% decrease of number of deaths caused by chronic illness. Furthermore, Tables 4 and 5 show that population density decreased numbers of deaths caused by chronic illness in the second period but not in the first period. This suggests that the effect of population density changed over time and so depended on socio-economic circumstance. Both *INCOM* and *HC* were not statistically significant in columns (1)–(3), whereas they yielded negative sign and were statistically significant at the 1% level in columns (4)–(6). Absolute values of *INCOM* ranged at 0.06–0.09 whereas *HC* was 0.05 when year dummies were included, suggesting that 1% increase of per capita income resulted in 0.06–0.09 decrease of deaths caused by chronic illness and 1% increase of those who graduated from university led to 0.05% decrease of deaths. On the other hand, as shown in columns (4)–(6), *SC* was not statistically significant when year dummies were included, although this variable took a significant negative sign in columns (1) and (3). *INCOM* and *HC* apparently made greater contributions to improvement of health status than *SC* in the period 1999–2009, in contrast to the results of the period 1998–2008. The roles played by *DENS, HC, SC*, and *INCOM* to improve health status and decrease deaths caused by chronic illness changed over time.

The validity of the fixed effects 2SLS estimation was assessed as follows. Since the p-values of the over-identification test were >0.10, the results failed to reject the hypothesis that passed the over-identification test in all estimations. In the first period as shown in Table 6, *SC* took a significant negative sign in all estimations and absolute values are similar to those in Table 4. On the other hand, concerning the second period shown in Table 7, *DENS* took a significant negative sign. Absolute values of *DENS* ranged at 0.13-0.15, which are slightly larger than those in Table 5. *HC* did not yield the expected positive sign and was not statistically significant in columns (1)–(3), whereas *HC* produced the expected significant negative sign in columns (4)–(6). Absolute values of *HC* ranged at 0.09–0.10, which were approximately twice larger than those in Table 5. That is, 1% increase of HC led to 0.09–0.10 decrease of number of deaths caused by chronic illness. Inconsistent with the results of Table 5, *INCOM* was not statistically significant in columns (1)–(6), indicating that per capital income did not influence health status and so deaths caused by chronic illness. In summary, apart from *INCOM*, the regression estimates concerning the key variables were hardly affected by controlling for endogeneity bias, suggesting that the estimation results are robust.

5. Conclusion

Among lifestyle-related problems, efforts to reduce the rate of obesity and prevent chronic disease have attracted special attention as government policy issues, especially in developed countries. It is widely known that exercise and moderate calorie intake benefit health. Lifestyle might vary with the degree of urbanization, which generates benefits and risks at the same time. Although previous studies pointed out that urban residents may enjoy easier access to health care facilities and medical services, resulting in better maintenance of health (Rabinowitz and Paynter, 2002), the positive externality generated by congestion has not been examined. Using panel data for the years 1988–2009 in Japan, this paper explored how externalities from congestion, human capital, and socio-economic factors influenced deaths caused by chronic illness.

First, it was found that, after controlling for medical services represented by the number of hospitals, the number of deaths was not associated with population density in the first period 1988–1998 whereas it was negatively associated in the second period 1999-2009. This finding suggests that there is a positive externality of congestion on lifestyle and health status when effect of chronic illness becomes serious. Unintended exercise of workers during commuting time might make a positive contribution to health. Second, human capital decreased the number of deaths, and the effect was observed in the second period but not in the first period. Contrariwise, social capital was negatively related to number of deaths in the first period but not in the second period. It is thus concluded that social capital and human capital are substitutes and their roles changed over time. Human capital became more important than social capital as society became more modernized.

What came out most clearly from this investigation was the very substantial role played by human capital and the positive externality stemming from congestion in improving health status, which is affected by different socio-economic circumstances. In modernized society, positive externality of congestion increases the importance in improving health status through unintended exercise. Evidence concerning externality of congestion is in obvious contrast with the view that congestion in urban areas reduces the number of amenities. The positive externality of congestion should be taken into account when benefits and risks are evaluated.

This research was based on data aggregated at the prefectural level. Individual characteristics such as age, marital status, amount of exercise, and BMI were not considered. Hence the ways and the extent to which unintended exercise was associated with BMI and chronic illness were not directly examined. More importantly, cohort effects on chronic illness seem critical because lifestyle depends on age. Therefore a future direction of study will be to use individual data to control for unobserved factors in this study and to investigate relations between unintended exercise and chronic illness so as to corroborate the arguments raised in this paper.

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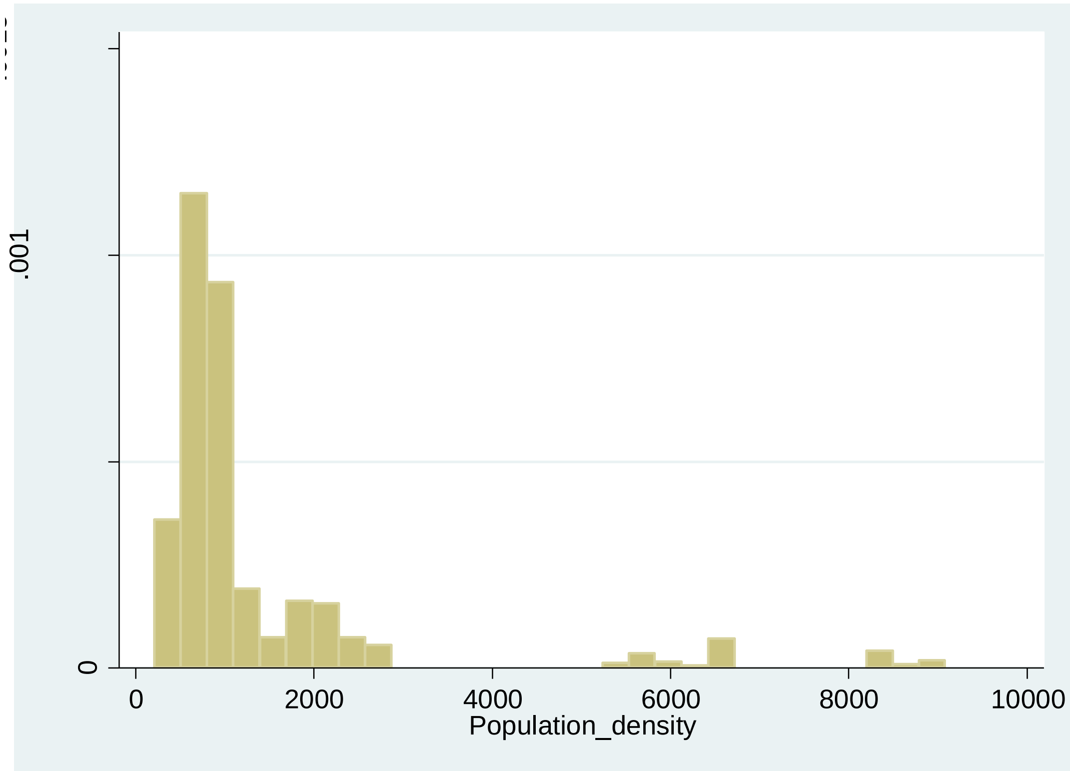
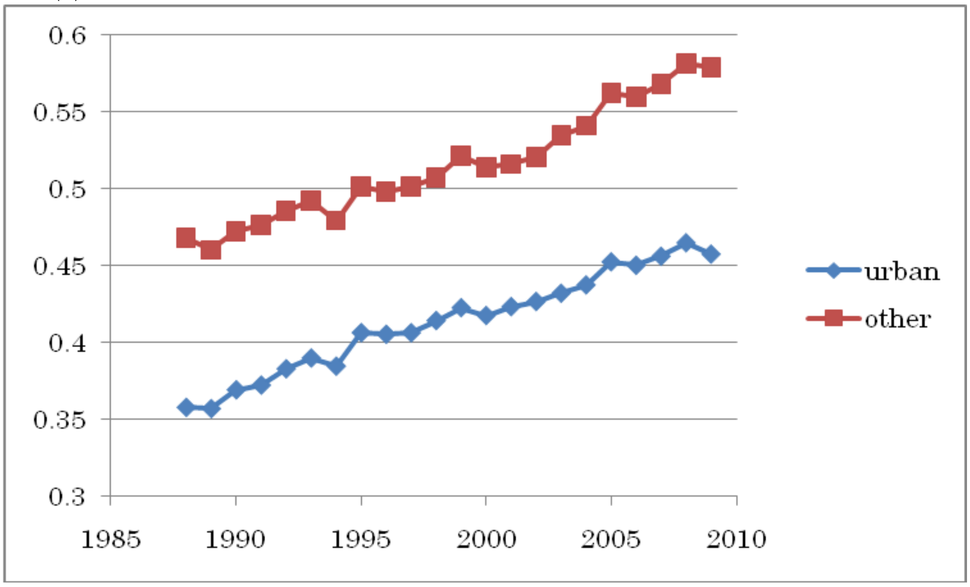


Figure 1. Histogram of population density.
Population density was measured by no. persons/km^2 of habitable land areas.

(a) Urban and other areas



(b) Men vs. women

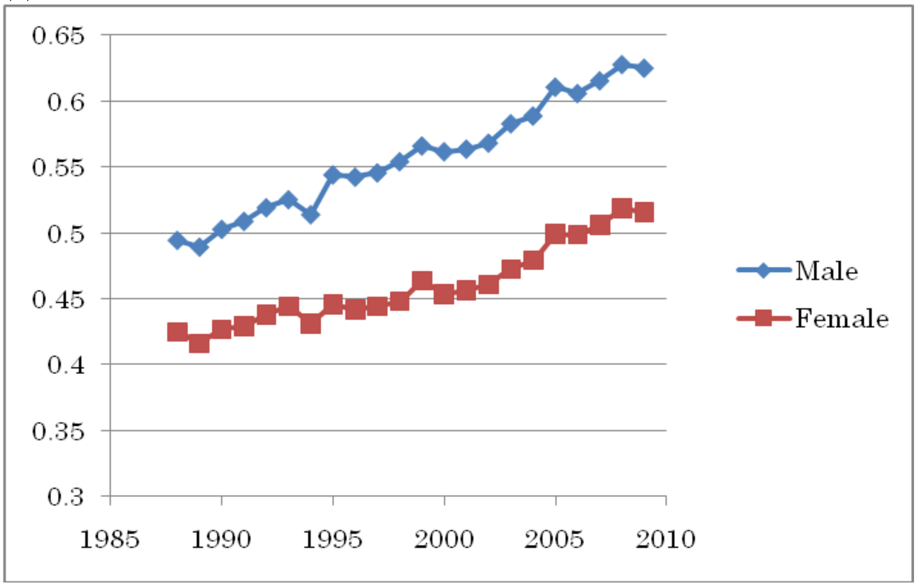
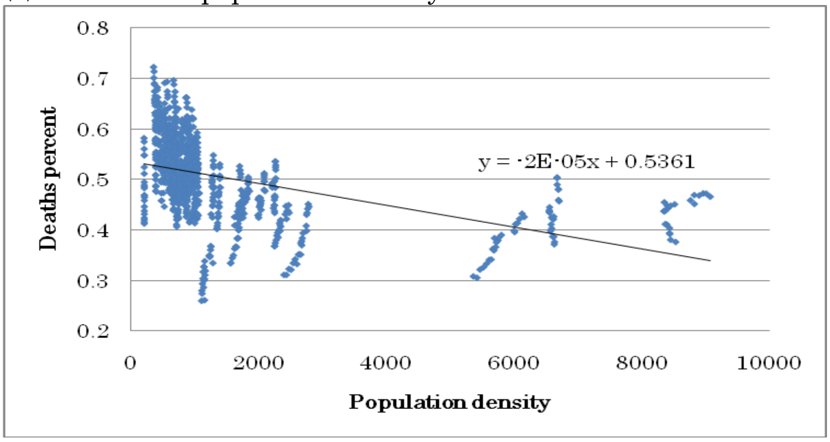
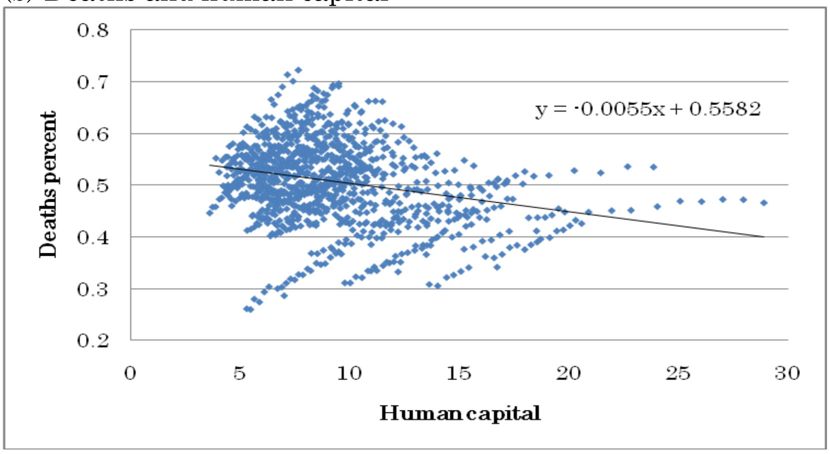


Figure 2. Deaths caused by chronic illnesses as a percentage of the population.
In panel (a) values for men were calculated by no. male deaths and the male population and values for females were calculated similarly. In panel (b) urban areas comprising the top 5 most densely populated prefectures in 2009: Tokyo, Kanagawa, Saitama, Aichi, and Osaka.

(a) Deaths and population density



(b) Deaths and human capital



(c) Deaths and no. hospitals per capita

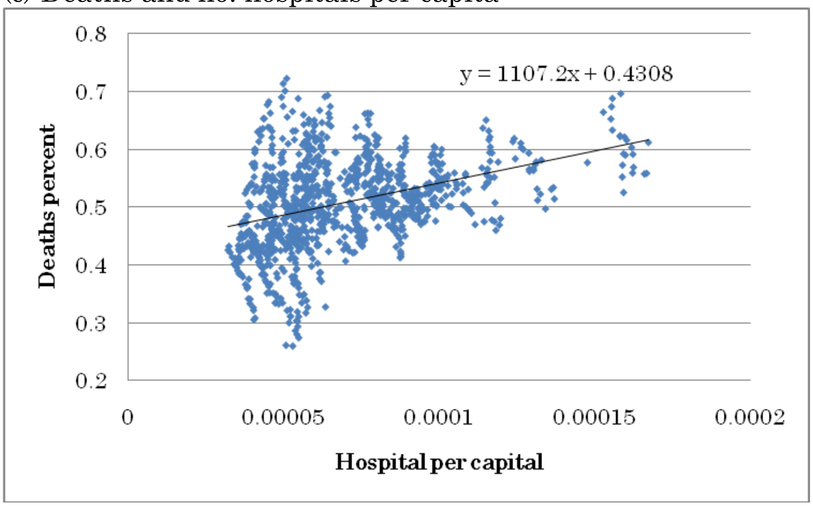


Figure 3. Simple regression equations of deaths plotted against human capital and population density.
Deaths caused by chronic illnesses as a percentage of the population were used for death percentages. The human capital index is the number of people who graduated from university as a percentage of the population.

Table 1 Descriptive statistics

Variables	Definition	Mean	SD
HOSPITAL	No. hospitals for internal diseases per population	$0.68*10^{-4}$	$0.25*10^{-4}$
DENS	Population density (Population/habitable land area [km^2])	1357	1594
SC	No. community centers per capita	$2.16*10^{-4}$	$1.63*10^{-4}$
INCOM	Per capita income (thousand yen/month)	2809	414
HC	No. people who graduated from university per population (%)	9.3	0.4
BOOZE	Per capita consumption of all types of alcoholic drinks (liters)	70.7	9.8
SERVICE	Rate of employment in service sector (%)	30.7	0.29
*AGE60_*	Proportion of population of people aged >60 years (%)	19.1	7.2
YEAR9709	1997-2009 years dummy variable (1 during 1997 and 2009, otherwise 0)	0.59	0.49
YEAR9909	1999-2009 years dummy variable (1 during 1999 and 2009, otherwise 0)	0.50	0.50

Source: Asahi Shimbunsha (2006), Index Corporation (2006), Statistics Bureau of the Ministry of Internal Affairs and Communications (various years).

Table 2
Determinants of death caused by chronic illnesses as a percentage of the population (fixed effects model)

	(1) All	(2) Men	(3) Women	(4) All	(5) Men	(6) Women
HOSPITAL	-0.04** (-2.01)	-0.04* (-1.95)	-0.03 (-1.58)	-0.06*** (-3.38)	-0.06*** (-3.52)	-0.04** (-2.23)
DENS	-0.12*** (-5.01)	-0.09*** (-3.49)	-0.17*** (-6.16)	-0.01 (-0.56)	0.01 (0.52)	-0.05** (-2.04)
SC	-0.02*** (-3.38)	-0.03*** (-3.34)	-0.02*** (-2.80)	-0.008 (-1.21)	-0.009 (-1.31)	-0.006 (-0.80)
INCOM	0.07*** (3.42)	0.08*** (3.70)	0.05** (2.48)	-0.07*** (-3.83)	-0.08*** (-3.97)	-0.06*** (-2.78)
HC	0.01 (0.90)	0.02* (1.83)	-0.002 (-0.15)	-0.06*** (-5.75)	-0.05*** (-4.14)	-0.08*** (-5.82)
BOOZE	0.13*** (6.33)	0.18*** (8.00)	0.08*** (3.57)	0.08*** (3.60)	0.05** (2.19)	0.11*** (4.41)
SERVICE	0.36*** (9.84)	0.35*** (9.07)	0.36*** (8.84)	0.02 (0.53)	0.03 (0.79)	0.007 (0.14)
*AGE60_*	0.12*** (21.0)	0.12*** (18.8)	0.13*** (19.7)	0.38*** (13.2)	0.48*** (15.2)	0.28*** (8.16)
YEAR9709	0.002 (1.21)	0.009*** (4.11)	-0.005** (-2.25)			
YEAR9909	0.008*** (4.31)	0.008*** (3.72)	0.009*** (4.04)			
YEAR dummy				Yes	Yes	Yes
Sample	1012	1012	1012	1012	1012	1012
Groups	46	46	46	46	46	46
Adj R-square	0.84	0.84	0.78	0.90	0.90	0.86

Numbers in parentheses are t-statistics. *, **, and *** indicate significance at 10%, 5%, and 1%, respectively. Numbers are the elasticity evaluated at the sample mean values of the variables. "Yes" means that year dummies are included.

Table 3
Determinants of death caused by chronic illnesses as a percentage of the population (fixed effects 2SLS model)

	(1) All	(2) Men	(3) Women	(4) All	(5) Men	(6) Women
HOSPITAL	-0.58***	-0.66***	-0.51***	-0.41***	-0.44***	-0.36****
	(-3.18)	(-3.25)	(-2.71)	(-3.92)	(-3.94)	(-3.15)
DENS	-0.15***	-0.12***	-0.20	-0.04	-0.02	-0.08***
	(-4.49)	(-3.35)	(-5.64)	(-1.61)	(-0.75)	(-2.68)
SC	-0.03***	-0.04***	-0.03***	-0.01	-0.01	-0.01
	(-3.30)	(-3.24)	(-2.95)	(-1.54)	(-1.62)	(-1.14)
INCOM	0.13***	0.15***	0.11***	-0.05**	-0.05**	-0.04
	(3.85)	(4.02)	(3.15)	(-2.15)	(-2.27)	(-1.62)
HC	-0.04*	-0.04	-0.05**	-0.09***	-0.08***	-0.10***
	(-1.82)	(-1.44)	(-2.01)	(-5.90)	(-4.74)	(-5.92)
BOOZE	0.15***	0.20***	0.10***	0.07***	0.04	0.11***
	(5.45)	(6.57)	(3.56)	(2.80)	(1.63)	(3.76)
SERVICE	0.27***	0.26***	0.28***	0.06	0.07	0.04
	(4.91)	(4.23)	(5.02)	(1.12)	(1.33)	(0.69)
*AGE60_*	0.11***	0.11**	0.12***	0.45***	0.56***	0.34***
	(13.3)	(11.5)	(13.9)	(11.2)	(12.7)	(7.71)
YEAR9702	-0.008	0.005*	-0.008***			
	(-0.27)	(1.67)	(-2.70)			
YEAR9902	0.01***	0.01***	0.01***			
	(4.42)	(4.13)	(4.17)			
Year dummies				Yes	Yes	Yes
Sample	1012	1012	1012	1012	1012	1012
Groups	46	46	46	46	46	46
R-square	0.74	0.73	0.71	0.88	0.87	0.83
Over-identification test	Chi=3.25 p<0.07	Chi=4.29 p<0.03	Chi=1.28 p<0.25	Chi=0.74 p<0.38	Chi=0.41 p<0.57	Chi=0.64 p<0.42

Numbers in parentheses are t-statistics. *, **, and *** indicate significance at 10%, 5%, and 1%, respectively. Numbers are the elasticity evaluated at the sample mean values of the variables. The instruments for *HOSPITAL* were inhabited land area (HABLAND) and its log-form (lnHABLAND). “Yes” means that year dummies are included.

Table 4
Determinants of death caused by chronic illnesses as a percentage of the population for the period 1988–98 (fixed effects model)

	(1) All	(2) Men	(3) Women	(1) All	(2) Men	(3) Women
HOSPITAL	0.01	-0.02	0.06	-0.01	-0.03	0.01
	(0.33)	(-0.68)	(1.50)	(-0.42)	(-0.96)	(0.36)
DENS	-0.006	-0.05	0.03	0.05	0.02	0.07
	(-0.12)	(-0.91)	(0.60)	(1.00)	(0.39)	(1.14)
SC	-0.05***	-0.05***	-0.06***	-0.04***	-0.04***	-0.05***
	(-3.25)	(2.62)	(-3.14)	(-3.34)	(-2.82)	(-2.90)
INCOM	0.06**	0.10***	0.02	0.03	-0.003	0.07*
	(2.23)	(3.06)	(0.68)	(0.91)	(-0.09)	(1.68)
HC	0.04**	0.09***	-0.005	0.05	0.002	0.10*
	(2.09)	(3.57)	(-0.23)	(1.13)	(0.04)	(1.87)
BOOZE	0.08***	0.07**	0.10***	0.03	0.01	0.06
	(2.66)	(1.98)	(3.01)	(0.93)	(0.42)	(1.42)
SERVICE	0.42***	0.49***	0.35***	0.04	0.04	0.04
	(7.29)	(7.15)	(5.35)	(0.52)	(0.43)	(0.41)
*AGE60_*	0.04***	0.04***	0.03***	0.20***	0.17**	0.24***
	(5.78)	(5.65)	(4.50)	(3.33)	(2.52)	(3.22)
YEAR dummy				Yes	Yes	Yes
Sample	506	506	506	506	506	506
Groups	46	46	46	46	46	46
Adj R-square	0.60	0.65	0.34	0.72	0.77	0.45

Numbers in parentheses are t-statistics. *, **, and *** indicate significance at 10%, 5%, and 1%, respectively. Numbers are the elasticity evaluated at the sample mean values of the variables. "Yes" means that year dummies are included.

Table 5
Determinants of death caused by chronic illnesses as a percentage of the population for the period 1999-2009 (fixed effects model)

	(1) All	(2) Men	(3) Women	(1) All	(2) Men	(3) Women
HOSPITAL	-0.05**	-0.03	-0.09***	-0.02	-0.01	-0.03
	(-2.31)	(-1.13)	(-2.89)	(-0.99)	(-0.53)	(-1.06)
DENS	-0.25***	-0.22***	-0.30***	-0.11***	-0.12***	-0.12***
	(-7.65)	(-6.41)	(-7.31)	(-4.51)	(-4.04)	(-3.54)
SC	-0.01*	-0.01	-0.02*	-0.001	0.0002	-0.002
	(-1.78)	(-1.08)	(-2.04)	(-0.12)	(0.03)	(-0.22)
INCOM	0.02	0.02	0.02	-0.07***	-0.06***	-0.09***
	(0.97)	(0.97)	(0.73)	(-3.78)	(-2.58)	(-3.60)
HC	0.04**	0.03	0.05**	-0.05***	-0.05***	-0.05***
	(1.97)	(1.47)	(2.04)	(-3.35)	(-2.65)	(-2.74)
BOOZE	-0.12***	-0.07*	-0.17***	0.004	0.01	-0.008
	(3.20)	(-1.85)	(-3.81)	(0.18)	(0.47)	(-0.23)
SERVICE	0.13***	0.14***	0.13**	-0.03	0.03	-0.11
	(3.02)	(3.06)	(2.32)	(-0.76)	(0.68)	(-1.83)
*AGE60_*	0.12***	0.13***	0.12***	0.21***	0.38***	0.02
	(14.0)	(13.8)	(11.1)	(5.09)	(7.83)	(0.48)
YEAR dummy				Yes	Yes	Yes
Sample	506	506	506	506	506	506
Groups	46	46	46	46	46	46
Adj R-square	0.76	0.72	0.71	0.88	0.82	0.84

Note: Numbers in parentheses are t-statistics. *,** and *** indicate significance at 10, 5 and 1 per cent levels respectively. Numbers are the elasticity evaluated at the sample mean values of the variables. "Yes" means that year dummies are included.

Table 6
Determinants of death caused by chronic illnesses as a percentage of the population for the period 1988–98 (fixed effects 2SLS model)

	(1) All	(2) Men	(3) Women	(4) All	(5) Men	(6) Women
HOSPITAL	-0.30	-0.63	0.03	-0.45	-0.79	-0.07
	(-0.48)	(-0.76)	(0.05)	(-1.07)	(-1.42)	(-0.17)
DENS	-0.05	-0.15	0.03	0.07	0.05	0.07
	(-0.48)	(-1.02)	(0.28)	(1.09)	(0.63)	(1.15)
SC	-0.05***	-0.05**	-0.06***	-0.04***	-0.04*	-0.05***
	(-3.02)	(2.29)	(-3.02)	(-2.62)	(-1.79)	(-2.82)
INCOM	0.07**	0.11***	0.02	0.02	-0.02	0.06
	(2.12)	(2.63)	(0.67)	(0.48)	(-0.41)	(1.57)
HC	0.008	0.02	-0.008	0.02	-0.04	0.09
	(0.11)	(0.20)	(-0.11)	(0.35)	(-0.61)	(1.55)
BOOZE	0.14	0.19	0.11	0.04	0.03	0.06
	(1.11)	(1.12)	(0.81)	(0.95)	(0.53)	(1.43)
SERVICE	0.35**	0.35*	0.35**	-0.17	-0.33	-0.002
	(2.26)	(1.76)	(2.14)	(-0.75)	(-1.10)	(-0.01)
*AGE60_*	0.03	0.03	0.03*	0.42*	0.54*	0.28
	(1.55)	(1.10)	(1.66)	(1.95)	(1.90)	(1.29)
Year dummies				Yes	Yes	Yes
Sample	506	506	506	506	506	506
Groups	46	46	46	46	46	46
R-square	0.58	0.55	0.41	0.65	0.60	0.52
Over-identification test	Chi=2.33 p<0.12	Chi=2.63 p<0.10	Chi=0.73 p<0.39	Chi=0.006 p<0.93	Chi=0.06 p<0.79	Chi=0.06 p<0.80

Numbers in parentheses are t-statistics. *, **, and *** indicate significance at 10%, 5%, and 1%, respectively. Numbers are the elasticity evaluated at the sample mean values of the variables. The instruments for *HOSPITAL* were inhabited land area (HABLAND) and its log-form (lnHABLAND). "Yes" means that year dummies are included.

Table 7
Determinants of death caused by chronic illnesses as a percentage of the population for the period 1999–2009 (fixed effects 2SLS model)

	(1) All	(2) Male	(3) Female	(4) All	(5) Male	(6) Female
HOSPITAL	-0.37 (-1.49)	-0.05 (-0.24)	-0.74** (-2.01)	-0.87 (-1.27)	-1.07 (-1.28)	-0.63 (-1.02)
DENS	-0.23*** (-5.33)	-0.22*** (-5.65)	-0.24*** (-3.86)	-0.14*** (-2.59)	-0.15** (-2.27)	-0.13*** (-2.80)
SC	-0.02* (-1.86)	-0.01 (-1.06)	-0.03* (-1.94)	-0.01 (-0.87)	-0.01 (-0.82)	-0.01 (-0.76)
INCOM	0.04 (1.43)	0.03 (0.84)	0.08 (1.48)	-0.06 (-1.43)	-0.04 (-0.78)	-0.08** (-2.21)
HC	0.02 (0.71)	0.03 (1.16)	0.01 (0.23)	-0.10** (-2.06)	-0.10* (-1.80)	-0.09** (-2.06)
BOOZE	-0.14*** (3.05)	-0.07* (-1.76)	-0.22*** (-3.19)	-0.08 (-0.93)	-0.09 (-0.87)	-0.07 (-0.88)
SERVICE	0.05 (0.60)	0.14* (1.79)	-0.04 (-0.39)	0.11 (0.76)	0.21 (1.21)	-0.008 (-0.06)
*AGE60_*	0.10*** (5.83)	0.13*** (7.71)	0.08*** (3.03)	0.31*** (2.72)	0.50*** (3.59)	0.09 (0.97)
Year dummies				Yes	Yes	Yes
Sample	506	506	506	506	506	506
Groups	46	46	46	46	46	46
R-square	0.72	0.75	0.51	0.61	0.37	0.74
Over-identification test	Chi=0.32 p<0.56	Chi=0.88 p<0.34	Chi=0.03 p<0.85	Chi=0.11 p<0.73	Chi=0.23 p<0.62	Chi=0.00 p<0.98

Numbers in parentheses are t-statistics. *, **, and *** indicate significance at 10%, 5%, and 1%, respectively. Numbers are the elasticity evaluated at the sample mean values of the variables. The instruments for *HOSPITAL* were inhabited land area (HABLAND) and its log-form (lnHABLAND). “Yes” means that year dummies are included.